



## Sliding Performance of PEI Composites Under Dry Atmospheric Conditions

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In this work, the dry sliding wear behavior of PEI+15%PTFE and PEI+20%GFR polymer composites rubbing against PPS+40%SGFR, BMC+15%LGFR and stainless steel were investigated using a pin-on-disc arrangement. Test conditions were 20 to 60N loads and at 0.5 m/s sliding speeds. It was observed that, the specific wear rate showed very little sensitivity to the varying load. For all material combinations used in this investigation, the coefficient of friction decreases linearly with the increase in load. The specific wear rate decreases with the increase in applied load for polymer-polymer combinations but increases or shows no change with the increase in load value for polymer- steel disc combinations. Finally it is concluded that the wear resistance of 15% PTFE filled PEI composite is higher than that of 20% glass fibre reinforced poly-ether-imide polymer composite against different polymer and steel counter-faces.

**Keywords:** Composite, PEI; PPS, BMC, Steel

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### 1. INTRODUCTION

Friction and wear are one of the three most commonly encountered industrial problems leading to the replacement of components and assemblies in engineering; the other two are fatigue and corrosion. Lancaster (1990), Hutchings (1992) and Tewari et al (1989) reported that the friction between polymers can be attributed to two main mechanisms, deformation and adhesion. The deformation mechanism involves a complete dissipation of energy in the contact area. The adhesion component is responsible for the friction of polymer and is a result of the breaking of weak bonding forces between polymer chains in the bulk of the material, Hutchings (1992).

There have been numerous investigations exploring the influence of test conditions, contact geometry, and environment on the friction and wear behavior of polymers. Yamaguchi (1990), Hooke et al (1996) and Lawrence et al (1989) report that the coefficient of friction can, generally, be reduced and the wear resistance with polymer sliding against steel improved by selecting the right material combinations. Santner et al (1989), Brentnall et. al. (1989) and Clerico (1969) observed that the friction coefficient of polymers rubbing against metals decreases with the increase in load while Yamaguchi (1990) showed that its value increases with the increase in load. Ludema et al (1966) showed good correlation between rolling coefficient friction and damping loss factor of polymeric materials in function of testing temperature. Watanabe et.al. (1986), Tanaka (1982) and Bahadur et al (1985) has reported the tribological behavior of polyamide, HDPE and their composites. They reported that their wear resistance and coefficient of friction is affected greatly by normal load, sliding speed and temperature.

The purpose of the study lay in exploring the influence of applied load values on the friction and

wear behavior of poly-ether-imides polymers. Friction and wear tests of the poly-ether-imide polymers versus steel, PPS+40%GFR and BMC+15%LGFR polymers were carried out on a pin-on-disc rig and at a dry sliding condition. Tribological tests were at room temperature, under 20, 40 and 60 N loads and at 0.5 m/s sliding speeds. The results are useful to guide the application of PEI polymers for wear-resistant component design.

### 2. EXPERIMENTAL DETAILS

Dry sliding wear tests were conducted on in house made pin-on-disc friction and wear testing machine. The cylindrical test specimens of size 6 mm diameter and 50 mm length were tested against PEI+15%PTFE, PEI+20%GFR polymer composite discs and steel discs of hardness 60 HRC. The test was conducted at different loads (20, 40 and 60 N) and 0.50 m/s sliding speed. The weight loss measured taken after 1000m of sliding distance. The specific wear rate values were calculated from the weight loss measurements. Sliding wear data reported here is the average of at least three runs. The pin-on-disc wear test rig that was designed and used for this work. Materials and the specific test conditions (i.e. Materials, ambient temperature, sliding speed and humidity) selected for this study is summarized in Table I.

### 3. RESULTS AND DISCUSSION

Figures 1 and 2 present the variation of friction coefficients of PEI+15%PTFE and PEI+20%GFR polymer composites with applied loads against different steel and PPS+40%GFR and BMC+15%LGFR polymer composite counter-faces. For both PEI+20%GFR and PEI+15%PTFE polymer composites at the range of applied loads used in this investigation, the coefficient of friction decreases linearly with the increase

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in applied load. For the variation in applied load, in the case of PEI+20%GFR/PPS+40%GFR and PEI+20%GFR/BMC+15%LGFR couples there are an average 33% and 33% decrease in friction coefficient value for a 200% increase in load respectively while for PEI+20%GFR/ steel, there is about 13% decrease in friction coefficient value for a 200% increase in load. For the variation in applied load, in the case of PEI+15%PTFE/PPS+40%GFR and PEI+15%PTFE /BMC+15%LGFR and PEI+15%PTFE/ steel couples there are an average 33%, 30% and zero decrease in friction coefficient value for a 200% increase in load respectively. It is known that the tribological behavior of polymers and polymer composites can be associated to their visco-elastic and temperature related properties. Sliding contact of two materials results in heat generation as asperities and hence increase in temperature at the frictional surfaces of the two materials. The adhesive wear resistance of the polymer material depends on the quantity of heat generated. The coefficient of friction decreases with the applied load increase. But when the load increase to the limit load of the polymer, the friction and wear will increase due to the critical surface energy of the polymer. Furthermore, this is explained as the frictional heat raised the temperature of the friction surfaces,

which lead to relaxation of polymer molecule chains. In the meantime, molecules of polymer surfaces were pressed, drawn and sheared. Highly active radicals could react with unbroken chains, giving rise to a series of new chain.

Figures 3 and 4 illustrate the variation of specific wear rate with applied load. In general the specific wear rate for PEI+15%PTFE polymer composite against PPS+40%GFR, BMC+15%LGFR and steel were in the order of  $10^{-14}$  m<sup>3</sup>/Nm, while the specific wear rate value for PEI+20%GFR composite was in the order of  $10^{-13}$  m<sup>3</sup>/Nm. The lowest wear rate is for PEI+15%PTFE polymer against PPS+40%GFR composite with a value of  $7.94 \times 10^{-14}$  m<sup>3</sup>/Nm. The highest wear rate is for PEI+20%GFR composite against BMC+15%LGFR composite with a value of  $1.8 \times 10^{-13}$  m<sup>3</sup>/Nm. The specific wear rates for PEI+15%PTFE polymer composites against PPS+40%GFR, BMC+15%LGFR and steel disc materials are 23, 17 and 8 times lower than that of PEI+20%GFR respectively. Except for PEI+20%GFR/ steel and PEI+15%PTFE/ steel, for other polymers couples tested in this investigation and within the applied load of 20-60N, it is shown that the specific wear rate of the material has influenced by applying load value and different counter-face materials.

Table 1 – Materials used in the experiments and test conditions

Materials	Density (gcm <sup>-3</sup> )	Test temperature (°C)	Load (N)	Speed (m/s)	Humidity (%)
PEI+15%PTFE	1,33	22±2.0	20	0.50	56+2
			40		
			60		
PEI+20%SGFR	1,42	18±2.0	20	0.50	67+2
			40		
			60		

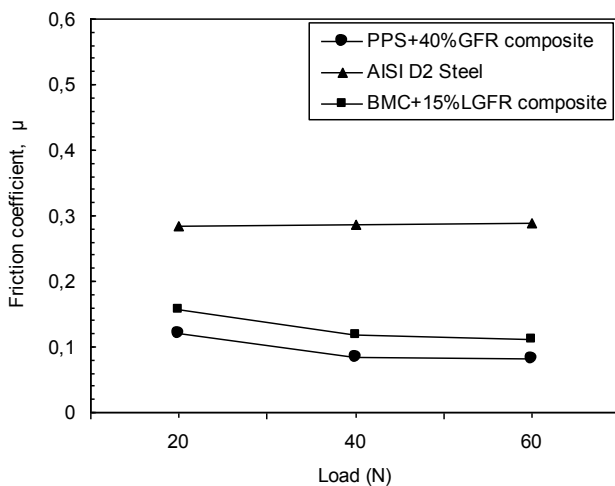


Fig. 1 – The relationship between friction coefficient and applied load values of PEI+15%PTFE composite against different counterface materials.

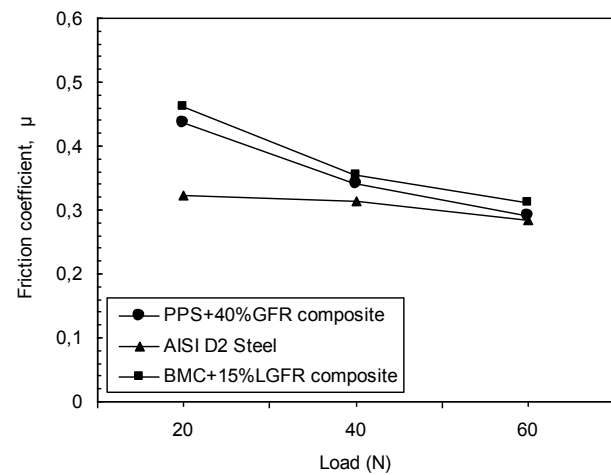
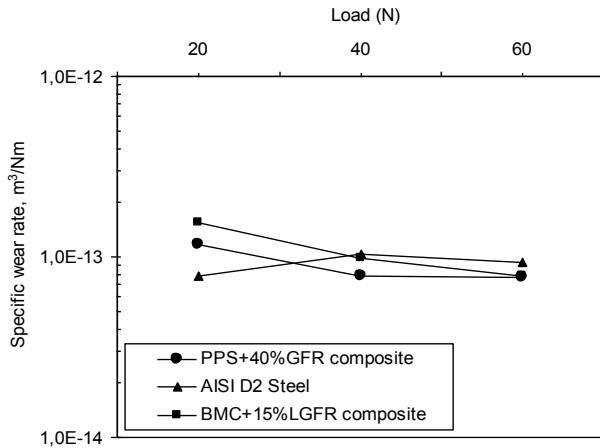


Fig 2 – The relationship between friction coefficient and applied load values of PEI+20%GFR composite against different counterface materials.



**Fig. 3** – The relationship between specific wear rate and applied load values of PEI+15%PTFE composite against different counterface materials.

#### 4. CONCLUSIONS

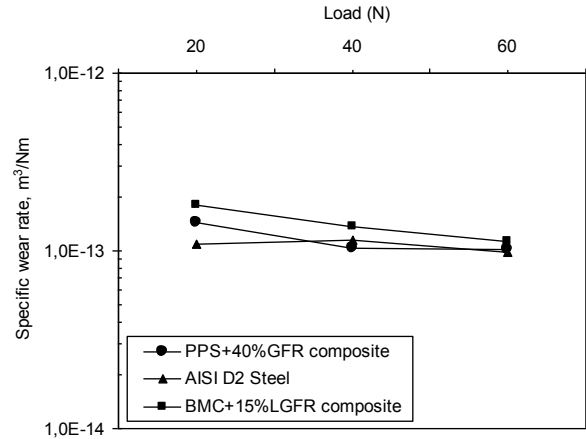
1. At the range of applied load studied in this work. The friction coefficient values of PEI+15%PTFE and PEI+20%GFR polymer composites linearly decreases with applied load.

2. The specific wear rates of PEI+15%PTFE and PEI+20%GFR were in the order of  $10^{-13}$  m<sup>3</sup>/Nm.

3. The lowest specific wear rate was observed in PEI+15%PTFE and the highest is for PEI+20%GFR

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**Fig. 4** – The relationship between specific wear rate and applied load values of PEI+20%GFR composite against different counterface materials.

polymer composite.

4. In general, the specific wear rate is not influenced by the change in applied pressure.

5. For the specific range of applied load and different counter-face explored in this study, the counterface material has a stronger effect on the wear rate of PEI+15%PTFE and PEI+20%GFR polymer composite than the applied load.

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